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Article

Effect of electric and magnetic fields on operation of insulin pumps under 400 kV power lines

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Abstract – The aim was to study the operation of insulin pumps under a 400 kV transmission line (two test places) and possible disturbances that the lines could have caused. Three different insulin pumps were attached one at a time to the subject's clothes. The diabetes nurse started the pumps before the tests to ensure the correct settings were being utilized. After walking under the power lines when meters were running, she tested if the meters had operated properly. At the first test site (A), the electric field was 5.0–5.1 kV/m and the magnetic field 8.6–10.9 μT, and in the second test place (B), the fields were 7.7–8.5 kV/m and 5.7–9.2 μT. The pumps worked perfectly: no disruption was detected in the flow, display or menu movement, and the events were registered correctly. Only the remote control, which worked well before and after the test, could not reliably receive additional doses. However, the functions of the insulin pump are not dependent on the functionality of the remote control device, so the study suggests that insulin pump users can move safely under the power lines.

Keywords: electromagnetic field / exposure / personnel / radiation / non-ionizing

1 Introduction

The use of insulin pumps has increased among children and adults with type 1 diabetes (Sherr *et al.*, 2016; Karges *et al.*, 2017), *e.g.*, from 0.6 to 1.3% in 1995 to 44 to 47% between 2012 and 2016 (Karges *et al.*, 2014; Bohn *et al.*, 2016; Szypowska *et al.*, 2016). However, according to Heinemann *et al.* (2015), with modern insulin pumps, errors of insulin infusion can occur due to pump failure, insulin infusion set (IIS) blockage, infusion site problems, insulin stability issues, user error, or a combination of factors (Heinemann *et al.*, 2015).

Electromagnetic field exposure guidelines for the general public describe that the general exposure limits may not sufficiently protect users of medical implants (European Recommendation, 1999; ICNIRP, 2010). Zradziński *et al.* (2018a) studied the effects of exposure to a low or intermediate frequency electromagnetic field (LIF-EMF), characterized by the electric field induced in the body, in order to evaluate how the type of insulin needle and the way it is injected influences the exposed user of a wearable insulin pump. They used numerical models of exposure scenarios. Based on the calculations they concluded that, when steel insulin needles were used, the assessment of users' EMF exposure should be carried out using magnetic field limits at least 5-times lower than given in the general international requirements (Zradziński *et al.*, 2018a).

The use of portable drug pumps, such as insulin pumps has increased, and their functions have become more diverse and sophisticated. Therefore, it is important to know more about their potential disruption, for example, when moving in the vicinity of power lines. The aim of the study is to investigate the operation and failures of insulin pumps under a 400 kV transmission line.

2 Measurement situations and methods

Insulin pumps were examined under the guidance of the diabetes nurse. Three different insulin pumps were attached one at a time to the subject's clothes. The diabetes nurse started the pumps before the tests to ensure the pumps would operate under the correct settings. After the test subject had walked under the power line, the nurse tested the operation of the equipment. The following devices were included in the study: 1) Paradigm Veo System (Medtronic); 2) ACCU-CHEK Spirit Combo including the remote control unit (Roche); and 3) Animas 2020 (Pharmanova Oy). The remote control of the ACCU-CHEK pump was also tested again. Two measuring

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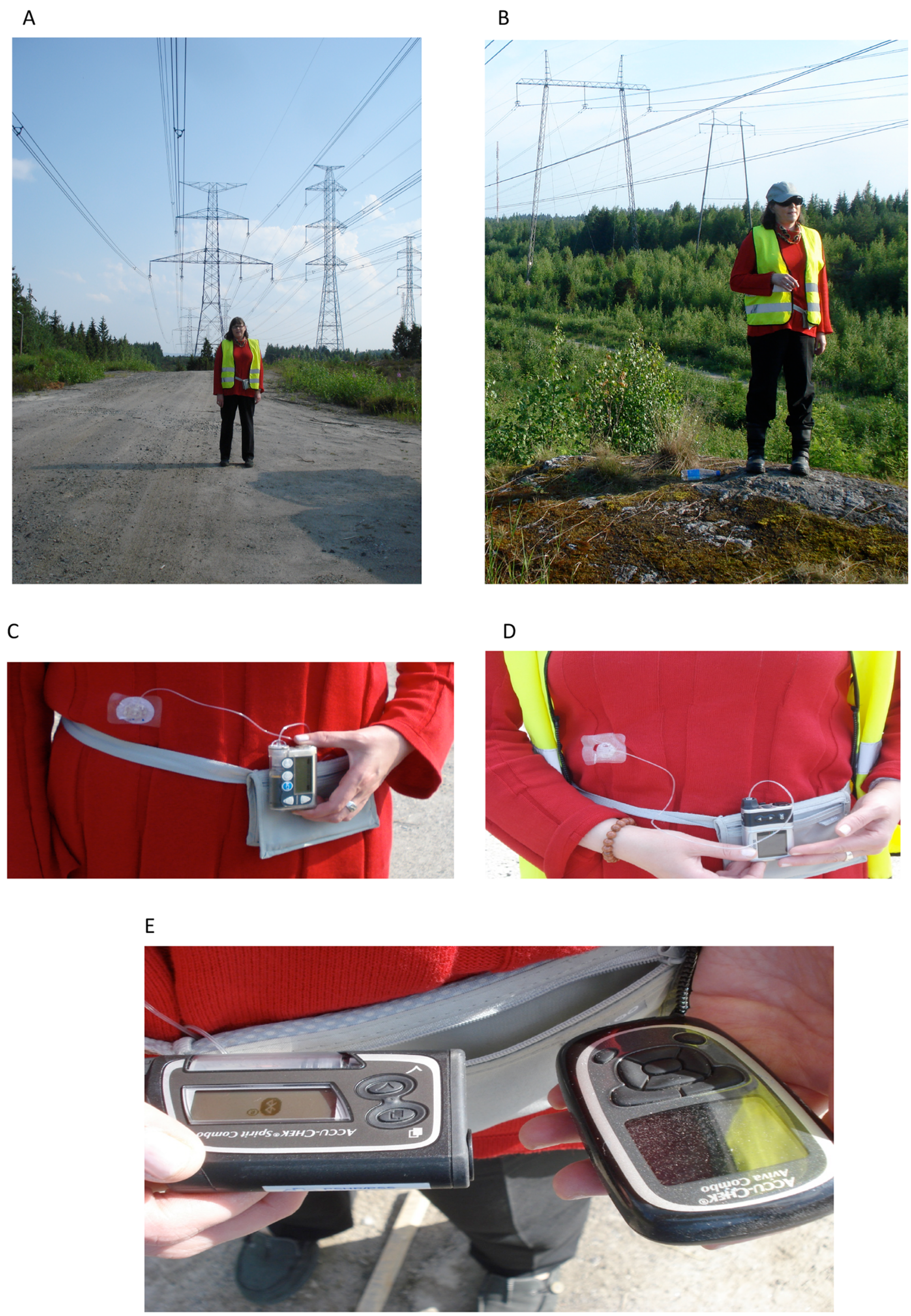

Fig. 1. Pictures under the power lines (a + b), and instrument set-up (c–e).

points were used under the power line. Figure 1 shows the measurement places near power lines (Figs. 1a and 1b) and also the tested devices (Figs. 1c–1e).

The base dose for the pumps was 1.3 U/h (units per hour). In both places, both the fast 4.0 U and the extended (30 min) 4.0 U additional doses were taken. The remote control device of the ACCU-CHEK pump also received a rapid additional dose of 4.0 U. The remote control device was subsequently tested again with an additional dose of 4.0 U. Figure 2 shows the test protocols.

We performed the electric field measurements with a commercial EFA-300 meter, using the three-axis E-Field Probe 2245-302 attachment (accuracy: 3%, rms) calibrated by the manufacturer (Narda Safety Test Solutions GmbH, Pfullingen, Germany). The frequency range was 5–30 kHz, the measurement height was 1.7 m, and the magnetic fields were measured with a Narda ELT-400 meter (L-3Communications, Narda Safety Test Solutions, Hauppauge, NY, USA) (accuracy ± 4% RMS), which has a frequency range of 1 Hz–400 kHz.

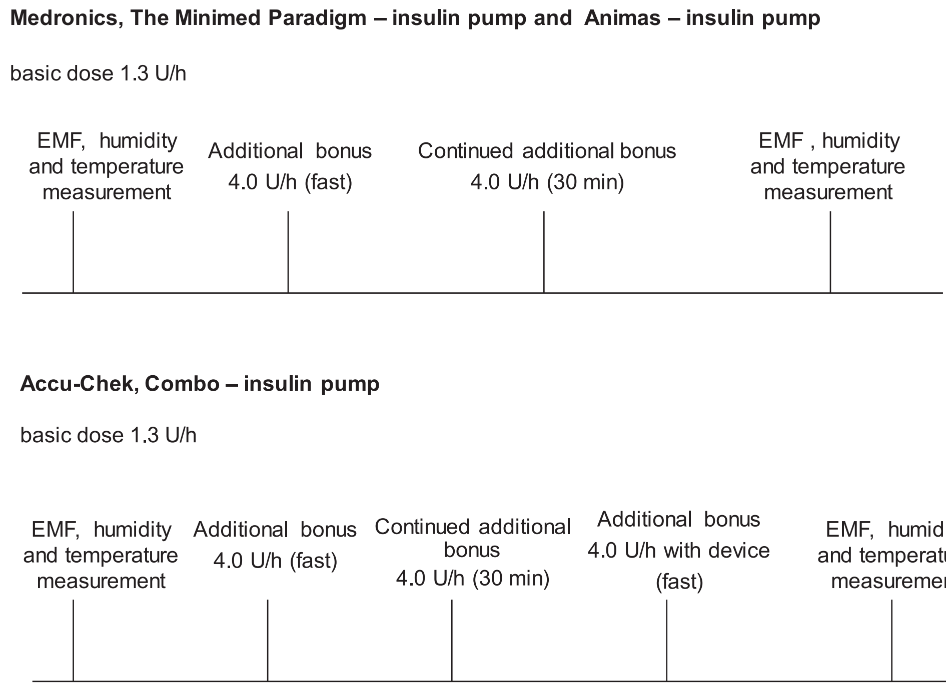

Fig. 2. Dosage and measurement protocols.

Table 1. Electric and magnetic fields at measurement places.

No.	Place	Magnetic field (μT)	Electric field (kV/m)
1	A	9.0–10.0	5.1
2	A	8.6–9.0	5.1
3	A	10.4–10.9	5.1
4	A	9.7–10.2	5.0
5	B	5.7–6.1	8.1
6	B	6.5–7.4	7.9–8.5
7	B	8.4–8.7	7.7–7.8
8	B	8.6–9.2	7.8

3 Results and discussion

During the tests, the electric field measured at the power line at site A was 5.0–5.1 kV/m, with the magnetic field in the range of 8.6–10.9 μT; and at site B, the fields were 7.7–8.5 kV/m and 5.7–9.2 μT. The measurement height was 1.7 m. The temperature was between 21.6–30.0 °C and the humidity varied from 44 to 63% (Tab. 1).

The pumps worked properly: no disruption was detected in the flow, display, or menu movement and the events were registered correctly. Only the remote control, which worked well before and after the test, could not reliably receive additional doses under the power lines. However, the functions of the insulin pump are not dependent on the functionality of the remote control device; thus, the study suggests that insulin pump users can move well under power lines.

We searched in PubMed using (1) (insulin pump) AND (power line); (2) (insulin pump) AND (electric field); (3) (insulin pump) AND (magnetic field). We did not find any experiments under power lines. Zradziński *et al.* (2018b), evaluated of the safety of users of active implantable medical devices (AIMD) in the working environment in terms of exposure to electromagnetic fields. However, they did not report results of insulin pumps under power lines.

4 Conclusion

The functions of the insulin pump are not dependent on the functionality of the remote control device; hence, the study suggests that insulin pump users can move safely under power lines.

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References

Bohn B *et al.* 2016. DPV Initiative. 20 years of pediatric benchmarking in Germany and Austria: Age-dependent analysis of longitudinal follow-up in 63 967 children and adolescents with type 1 diabetes. *PLoSOne* 11(8): e0160971.

European Recommendation. 1999. Council of the European Union Recommendation on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz), 1999/519/EC, OJ. L 199/59.

Heinemann L, Fleming GA, Petrie JR, Holl RW, Bergenstal RM, Peters AL. 2015. Insulin pump risks and benefits: A clinical appraisal of pump safety standards, adverse event reporting, and research needs. A Joint Statement of the European Association for the study of diabetes and the American Diabetes Association, Diabetes Technology Working Group. *Diabetes Care* 38: 716–722. https://doi.org/10.2337/dc15-0168.

International Commission on Non-Ionizing Radiation Protection (ICNIRP). 2010. Guidelines for limiting exposure to time-varying electric and magnetic fields (1 Hz–100 kHz). *Health Phys.* 99: 818–836.

Karges B *et al*. 2014. Hemoglobin A1c levels and risk of severe hypoglycemia in children and young adults with type 1 diabetes from Germany and Austria: A trend analysis in a cohort of 37 539 patients between 1995 and 2012. *PloS Med*. 11(10): e1001742.

Karges B, Schwandt A, Heidtmann B, Kordonouri O, Binder E, Schierloh U, Boettcher C, Kapellen T, Rosenbauer J, Holl RW. 2017. Association of insulin pump therapy vs. insulin injection therapy with severe hypoglycemia, ketoacidosis, and glycemic control among children, adolescents, and young adults with type 1 diabetes. *JAMA.* 318(14): 1358–1366.

Sherr JL, Hermann JM, Campbell F, Foster NC, Hofer SE, Allgrove J, Maahs DM, Kapellen TM, Holman N, Tamborlane WV, Holl RW, Beck RW, Warner JT. 2016. For the T1D Exchange Clinic Network, the DPV Initiative, and the National Paediatric Diabetes Audit and the Royal College of Paediatrics and Child Health registries, Use of insulin pump therapy in children and adolescents with type 1 diabetes and its impact on metabolic control: Comparison of results from three large, transatlantic paediatric registries. *Diabetologia* 59: 87–91. https://doi.org/10.1007/s00125-015-3790-6.

Szypowska A, Schwandt A, Svensson J, Shalitin S, Cardona-Hernandez R, Forsander G, Sundberg F, De Beaufort C, Maahs D, Maffeis C, O'Riordan SM, Krisane ID, Scharf M, Castro S, Konstantinova M, Obermannova B, Casteels K, Göksen D, Galhardo J, Kanaka-Gantenbein C, Rami-Merhar B, Madacsy L. 2016. SWEET Study Group. Insulin pump therapy in children with type 1 diabetes: Analysis of data from the SWEET registry. *Pediatr. Diabetes* 17(Suppl 23): 38–45.

Zradziński P, Karpowicz J, Gryz K. 2018a. In silico modelling of influence from low or intermediate frequency magnetic fields on users of wearable insulin pumps. *Int. J. Radiat. Biol.* 94(10): 926–933. https://doi.org/10.1080/09553002.2017.1419305.

Zradziński P, Karpowicz J, Gryz K, Leszko W. 2018b. Evaluation of the safety of users of active implantable medical devices (AIMD) in the working environment in terms of exposure to electromagnetic fields – Practical approach to the requirements of European Directive 2013/35/EU. *Int. J. Occup. Med. Environ. Health* 31(6): 795–808. https://doi.org/10.13075/ijomeh.1896.0783.

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